RTCA Special Committee SC-209
Transponder MOPS
Meeting #5
DO-181D Section 1.4.3.6
Proposed Breakdown of Level 2 transponders into Subclasses

Prepared by: Raymond Bayh
Presented by: Raymond Bayh
BAE Systems

SUMMARY:
This working paper presents a proposed breakdown of Level 2 Transponders into subclasses to meet today's airspace requirements; and to add the SI Capability

When the original Mode S transponder requirements were established, many various uplink and downlink services were envisioned which drove the requirements for data link transponders providing uplink Comm-A and downlink Comm-B services. But as today's airspace Mode S requirements have matured, the uses of the Mode S surveillance services have evolved primarily into downlink transmission of aircraft parameters with virtually no use of the Mode S uplink.

ICAO SARPS for global flight operations, the European Mode S mandate and the impending ADS-B equipage require the use of a Level 2 transponder operation. Obtaining the TSO/ETSO certification for Level 2 transponders requires full compliance to RTCA/DO-181C or Eurocae ED-73B MOPS including all Comm-A and Comm-B protocols. An Air Data Link Processor (ADLP) is needed to support Comm-A and Comm-B data link communications; yet, most of those services are without a defined use, creating cost and effort to produce and certify these transponders, as well as the costs to certify the installation on the aircraft.

To provide today's services, Elementary Surveillance (ELS) and Enhanced Surveillance (EHS) requires the use of GICB protocols and Comm-B Broadcast without the use of Directed Comm-B and Air-Initiated Comm-B protocols or the use of any uplink protocols. Automatic Dependent Surveillance –Broadcast (ADS-B) Out transponder registers are loaded using GICB protocols; the addition of ADS-B protocol provides that service. For today's airspace requirements and for next 15 years, a Mode S transponder essentially need only support the GICB protocols and ADS-B protocols, if desired.

This paper proposes to break-down Level 2 transponders into sub-classes thus providing ability for transponder manufacturers and airlines to specify Level 2 transponders capabilities that are more in line with today's requirements without the burden of supporting protocols that are not in use today. This division of Level 2 into subclasses will yield benefits by reducing equipment design, testing and manufacturing costs; aircraft installations efforts; and certification costs to demonstrate compliance with requirements that are not relevant for specific applications.

This paper proposes the following additional Level designations:

- Level 2A to signify a full data link capable transponder, meeting all requirements of Section 2.2.19 of RTCA/DO-181. The Level 2A data link transponder requirements will cover legacy Level 2 transponders as well as any new data link transponder designs.
- Level 2B to signify a Level 2 transponder that supports GICB and Comm-B Broadcast protocols only. Applications include ELS and EHS services.

A compliance matrix for each Level 2 sub-class shall detail the minimum requirements for each Level to aid the manufacturer in requirements definition, and meeting test and certification requirements. A draft of the Level 2 Compliance Matrix is provided at the end of the paper which will be ultimately placed in section 2.2.

The following shall be added to section 1.4 (Mode S Transponder) of DO-181D as follows:

All Level 1, 2A and 2B transponders will have the same Common Package requirements containing:

- Error Protection
- Lockout /Multisite Lockout Protocols
- Acquisition squitter
- Flight Status and Vertical Status Protocols
- All-Call Reply Protocols
- Capability Reporting
- Interrogation Acceptance and Reply Coordination
- Data Handling and Interfaces

The transponder levels and capabilities can then be broken down in the following table:

Functional Requirements	**Transponder Levels[1]**		**Additional Capabilities[3]**				
	2A	**2B**	**CLINK**	**ELS**	**EHS**	**TCAS**	**ADS-B**
Common Package	X	X					
GICB	X	X					
Comm-B Broadcast	X	X					
Data Link Capability Report	X	X					
Flight ID	X	X					
Comm-A	X						
Air-Initiated Comm-B	X						
Multisite Message Protocols	X						
SI Codes[2]	X	X					
Crosslink (See §2.2.19.1.17)			X				
Elementary Surveillance (See §2.2.24)				X			
Enhanced Surveillance (See §2.2.25)					X		
Comm-U/V						X	
TCAS (See §2.2.22)							
ADS-B Protocols (See §2.2.23)							X

Notes:

1. *The shaded area represents the basic capabilities of Level 2A and 2B Transponders.*
2. *SI Codes are required by Annex 10, Volume IV, §2.1.5.1.7.1.*

3. *Air Space managers may require these additional capabilities, depending on airspace requirements.*

The proposed changes to Section 1.4.3.2 of Do-181D, V0.5 are as follows:

1.4.3.2 Level 2 Transponders
The Level 2 Transponder supports all of the surveillance functions. It can also support:

a. bidirectional air-to-air information exchange
b. ground-to-air data uplink, Comm-A
c. air-to-ground data downlink, Comm-B
d. multisite message protocol
e. data link capability reporting
f. aircraft identification reporting
g. ACAS crosslink capability

Level 2 Transponders support receipt and processing of long interrogations and the generation of long replies. The ground-air-ground data link capability comprises a multitude of services and can be implemented according to the number and kind of services available, depending on the mission requirements of the aircraft. Protocols provide a means of reporting to the ground the specifics of each individual installation.

1.4.3.2.1
Level 2 transponders will have the following additional capabilities as defined by their subclass designation. The subclasses will provide the following transponder capabilities:

a. Ground-Initiated Comm-B (GICB) transponders will have the capabilities of §1.4.3.1 and those identified for Level 2B.

b. Level 2A Data Link transponders will have the capabilities of §1.4.3.1 and §2.2.19.

Paragraph 1.4.3.6 of Do-181D, V0.5: Additional Features did not include references to the SI Capable transponder. This paper also proposes to add a subclass designation for a TCAS compatible transponder. The following additions to paragraph 1.4.3.6 are as follows:

1.4.3.6 Additional Features
Some transponder installations will require additional features:

• Installations in large aircraft or co-installation with airborne collision avoidance systems may require the transponder to operate in the diversity mode, i.e., the use of two antennas, receivers and transmitting channels.

• Co-installation with TCAS II systems requires capability for long air-to-air formats.

• Co-installation with other L-band equipment may require an on-board mutual suppression system.

• Extended squitter transponders will have the capabilities of §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5 and also those prescribed for extended squitter operation (See §2.2.23). ~~Transponders with this capability will be designated with a suffix "e."~~

- Transponders with the ability to process SI codes will have the capabilities of §1.4.3.2 and also those prescribed for SI code operation

- TCAS Compatible transponders will have the capabilities of §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5, and §2.2.22.

Level 2 Subclass Compliance Matrix

DO-181D Paragraph	**DO-181D Requirement**	Level 2B GICB Protocols only	Level 2A Full Data Link
2.2.19	Minimum Level 2 Transponder Description	X	X
2.2.19.1	Minimum Level 2 Transponder Requirements	X	X
2.2.19.1.1	Interrogation Acceptance protocol	(c) only	X
2.2.19.1.2	Error Protection	X	X
2.2.19.1.3	Information transfer	X	X
2.2.19.1.4	Interrogation Reply Coordination	X	X
2.2.19.1.5	Lockout Protocols	X	X
2.2.19.1.6	Flight and Vertical Status Protocols	X	X
2.2.19.1.7	Capability Report	X	X
2.2.19.1.8	Reply Content	X	X
2.2.19.1.9	UM Protocol		X
2.2.19.1.10	Comm-A Protocol		X
2.2.19.1.11	Broadcast protocol		X
2.2.19.1.12	Comm-B Protocol	GICB only	X
2.2.19.1.12.1	Data Source Designators	X	X
2.2.19.1.12.2	Extended Data Source Designators	X	X
2.2.19.1.12.3	Ground-Initiated Comm-B	X	X
2.2.19.1.12.4	Air-Initiated Comm-B		X
2.2.19.1.12.4.1	Comm-B Broadcast	X	X
2.2.19.1.12.5	Data Link Capability Report	X	X
2.2.19.1.12.6	Subfields in MB For DLCR **Paragraph should be eliminated – details now in Appendix B**	X	X
2.2.19.1.12.7	Coding of DLCR **Paragraph should be eliminated – details now in Appendix B**	X	X
2.2.19.1.12.8	Updating of DLCR	X	X

DO-181D Paragraph	**DO-181D Requirement**	Level 2B GICB Protocols only	Level 2A Full Data Link
2.2.19.1.13	Air Identification Reporting and AIS Aircraft ID Subfield in MB	X	X
2.2.19.1.14	Linked Comm-A Coding		X
2.2.19.1.15	Multisite Message protocol		X
2.2.19.1.16	Comm-U/V Protocol	X	X
2.2.19.1.17	Data Handling and Interfaces	GICBonly	X
2.2.19.1.18	TCAS Crosslink protocol	X	X
2.2.19.2	The Multisite Message protocol		X
2.2.19.2.1	Multisite Data Formats		X
2.2.19.2.1.1	Subfields in SD	§ (c) LOS; § (d) RRS; § (f) only	X
2.2.19.2.1.2	Subfields in UM for Multisite Protocols		X
2.2.19.2.2	Multisite Common Protocols		X
2.2.19.2.2.1	Multisite timers		X
2.2.19.2.2.2	Interrogator Identity report		X
2.2.19.2.3	Multisite Comm-B Protocol		X
2.2.19.2.3.1	Multisite Comm-B reservation		X
2.2.19.2.3.2	Multisite Directed Comm-B Transmissions		X
2.2.19.2.3.3	Multisite Comm-B Closeout		X
2.2.19.2.3.4	Automatic Comm-B Closeout		X
2.2.19.2.3.5	Significance of PC Command		X
2.2.22	TCAS Compatible Transponder		
2.2.23	Extended Squitter (except 2.2.23.3: Extended Squitter/Non Transponder Devices) (except 2.2.23.4: Extended Squitter Military Application		